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5        A HARDWARE CIRCUIT AND METHOD FOR AUTOMATICALLY  
CONFIGURING ON-THE-FLY A SUB-UNIT IN A SCSI MESSAGE

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10      BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to SCSI expander devices, and more particularly to using a SCSI 15 expander with a variety of SCSI target and SCSI initiator devices having different signal conditioning requirements.

Description of Related Art

20      In a system that utilizes the Packetized SCSI Protocol, there are two methods used for signal conditioning. A first signal conditioning method, called write precompensation (WPC), conditions the driving signal. A second signal conditioning method, 25 called adjustable active filtering (AAF), conditions the received signal. Unfortunately, the two signal conditioning methods are incompatible because an AAF input signal is overdriven if WPC is used. According to the SCSI specification, WPC signal conditioning is 30 mandatory while AAF signal conditioning is optional.

For the Packetized SCSI Protocol, a SCSI initiator and a SCSI target use a Parallel Protocol Request (PPR) message in negotiating parameters for a data transfer between the SCSI initiator and the SCSI target over a 35 SCSI bus. Execution of the Parallel Protocol Request message is done in two passes. The SCSI initiator

sends a PPR message to the SCSI target with required and/or requested transfer parameters. In response to this PPR message, the SCSI target returns a PPR message with its requirements and/or requests. Both the SCSI 5 initiator and the SCSI target agree on the least common denominator of parameters for the ensuing data transfers.

A precompensation enable control bit P\_EN is used in the PPR message to select whether write 10 precompensation is turned on or turned off. The device that sends the PPR message asserts precompensation enable control bit P\_EN if the device wants the other device to turn on write precompensation for its drivers. Conversely, the device that sends the PPR 15 message negates precompensation enable control bit P\_EN if the device implements adjustable active filtering, and wants write precompensation turned off.

This technique for activating write precompensation depending on support for adjustable 20 active filtering presents problems when using a SCSI expander that does not support adjustable active filtering because the method selected does not reflect the limitations of the SCSI expander. Figs. 1A to 1D illustrate four possible SCSI initiator and SCSI target 25 configurations using write precompensation and adjustable active filtering with a SCSI expander 102 that does not support adjustable active filtering.

In Fig. 1A, neither SCSI initiator 101 nor SCSI 30 target 103 supports adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI target 103 sets precompensation enable control bit P\_EN in the PPR message that is passed by SCSI expander 102 to SCSI initiator 101. When SCSI initiator 101 sends data to SCSI target 103 through SCSI expander 102 that does not 35 support adjustable active filtering, the message

correctly indicates that expander 102 requires write precompensation.

For a SCSI bus phase DATA IN, SCSI initiator 101 sets precompensation enable control bit P\_EN in the PPR message that is passed by SCSI expander 102 to SCSI target 101. When SCSI target 103 sends data to SCSI target 103 through SCSI expander 102 that does not support adjustable active filtering, the data transfer is successful because expander 102 required write precompensation. However, the system configuration of Fig. 1A is the only one that works successfully with SCSI expander 102.

In Fig. 1B, SCSI target 105 supports adjustable active filtering and SCSI initiator 104 does not support adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI target 105 negates precompensation enable control bit P\_EN in the PPR message that is passed by SCSI expander 102 to SCSI initiator 101. This message erroneously indicates to SCSI initiator 101 that SCSI expander 102 supports adjustable active filtering, which is incorrect.

In Fig. 1C, SCSI initiator 106 supports adjustable active filtering, and SCSI target 107 does not support adjustable active filtering. For a SCSI bus phase DATA IN, SCSI initiator 105 negates precompensation enable control bit P\_EN in the PPR message that is passed by SCSI expander 102 to SCSI target 107. This message also erroneously indicates to SCSI target 107 that SCSI expander 102 does not require write precompensation.

In Fig. 1D, SCSI initiator 108 supports adjustable active filtering and SCSI target 109 also supports adjustable active filtering. For a SCSI bus phase DATA IN, SCSI initiator 108 negates precompensation enable control bit P\_EN in the PPR message that is passed by SCSI expander 102 to SCSI target 109. This message erroneously indicates to SCSI target 109 that SCSI

expander 102 does not require write precompensation. For a SCSI bus phase DATA out, SCSI target 109 negates precompensation enable control bit P\_EN in the PPR message that is passed by SCSI expander 102 to SCSI 5 initiator 108. This message erroneously indicates to SCSI initiator 108 that SCSI expander 102 does not require write precompensation.

Since the state of the precompensation enable control bit in the PPR message considers only the 10 initiator and target, a SCSI expander is limited to working with initiator and targets that have the same signal conditioning as the SCSI expander. Consequently, a SCSI expander with a given signal 15 conditioning is useful only in limited system configurations.

#### SUMMARY OF THE INVENTION

According to one embodiment of the present invention, a device includes a first I/O bus-interface circuit, and an on-the-fly message manipulation circuit connected to the first I/O bus-interface circuit. The on-the-fly message manipulation circuit sets on-the-fly a pre-selected sub-unit of a pre-selected message-unit of a message to a pre-selected state as the pre- 25 selected message-unit is passed through the device.

The on-the-fly manipulation circuit also includes a message detector module having an input coupled to the first I/O bus-interface circuit, and a message-detected line. In response to information indicative 30 of the message on the input, the message detector module generates an active signal on the message-detected line.

The on-the-fly message manipulation circuit further includes a message-unit detector module having 35 a message-unit detected line. The message-unit detector module generates an active signal on the

message-unit detected line upon detecting the pre-selected message-unit of the message.

In addition, the on-the-fly message manipulation circuit further includes a message sub-unit state selection module coupled to the message-detected line and to the message-unit detected line. The message sub-unit state selection module sets the pre-selected sub-unit of the pre-selected message-unit of the message to the pre-selected state after receiving the active signal on the message-detected line, and the active signal on the message-unit detected line.

In yet another embodiment, a SCSI expander includes a first SCSI bus-interface circuit, a second SCSI bus-interface circuit, and a SCSI message manipulation circuit connected to the first and second SCSI bus-interface circuits. The SCSI message manipulation circuit is one embodiment of an on-the-fly message manipulation circuit. The SCSI message manipulation circuit sets a pre-selected sub-unit of a pre-selected message-unit of a SCSI message to a pre-selected state as the pre-selected message-unit is passed through the SCSI expander, i.e., on-the-fly. Hence, this SCSI expander can be used in a system that includes SCSI devices using any desired type of signal conditioning for example.

The SCSI manipulation circuit also includes a message detector module. The message detector module includes an input coupled to the first and second SCSI bus-interface circuits, and a message-detected line. In response to information indicative of the SCSI message on the input, the message detector module generates an active signal on the message-detected line.

The SCSI message manipulation circuit further includes a message-unit detector module having a message-unit detected line. The message-unit detector

module generates an active signal on the message-unit detected line upon detecting the pre-selected message-unit of the SCSI message.

The SCSI message manipulation circuit includes a  
5 message sub-unit state selection module coupled to the message-detected line and to the message-unit detected line. In one embodiment, the message sub-unit state selection module sets the pre-selected sub-unit of the pre-selected message-unit of the SCSI message to the  
10 pre-selected state after the signal on the message-detected line goes active, and the active signal on the message-unit detected line is received.

In another embodiment, the message sub-unit state selection module further includes an enable line. The  
15 message sub-unit state selection module sets the pre-selected sub-unit of the pre-selected message-unit of the SCSI message to the pre-selected state only when an active signal is on the enable line.

In one embodiment, the SCSI message is a SCSI  
20 Parallel Protocol Request Message (PPR message). One embodiment of the SCSI expander of this invention does not support adjustable active filtering signal conditioning. In another embodiment, the SCSI expander of this invention supports adjustable active filtering  
25 signal conditioning. In the embodiment for the SCSI PPR message, the pre-selected message-unit has a size of one byte and the pre-selected sub-unit is a precompensation enable control bit in that byte.

Herein, adjustable active filtering and adjustable  
30 active filtering signal conditioning are the same thing. Similarly, herein, write precompensation and write precompensation signal conditioning are the same thing.

In yet another embodiment of the present  
35 invention, a device includes a message manipulation circuit that in turn includes a message-detected line,

a message-unit detected line, and a message sub-unit state selection module connected to the message-detected line and to the message-unit detected line. The message sub-unit state selection module sets a pre-selected sub-unit of a pre-selected message-unit of a message to a pre-selected state after receiving an active signal on the message-detected line, and an active signal on the message-unit detected line.

In still another embodiment of the present invention, a SCSI expander includes a SCSI message manipulation circuit that in turn includes (a) a message detector module including a message decoder coupled to receive information indicative of a SCSI message from a SCSI bus, and a message-detected line connected to the message decoder where the message decoder generates an active signal on the message-detected line upon decoding the information indicative of the SCSI message; (b) a message-unit detector module including a counter wherein the counter counts message-units in the SCSI message, a message-unit selection register, a comparator connected to the counter and to the message-unit selection register, and a message-unit detected line connected to the comparator, where the comparator generates an active signal on the message-unit detected line upon receiving a value from the counter that has a pre-selected relationship to a value stored in the message-unit selection register to indicate that a pre-selected message unit has been detected, and (c) a message sub-unit state selection module connected to the message-detected line and to the message-unit detected line where the message sub-unit state selection module sets a pre-selected sub-unit of the pre-selected message-unit of the SCSI message to a pre-selected state upon receiving the active signal on the message-detected line, and the active signal on the message-unit detected line, as the

pre-selected message-unit passes through the SCSI expander.

The message sub-unit state selection module has an output bus having a plurality of output lines and a 5 first plurality of logic gates. An output terminal of each logic gate of the first plurality of logic gates is selectively coupled to and selectively decoupled from a different output line of the output bus. An input bus has a plurality of input lines where each 10 line in the plurality of input lines is connected to a first input terminal of a different logic gate in the first plurality of logic gates.

The message sub-unit state selection module also has a second plurality of logic gates. An output 15 terminal of each logic gate of the second plurality of logic gates is connected to a second input terminal of the different logic gate in the first plurality of logic gates. The message-detected line is connected to a first input terminal of each logic gate of the second 20 plurality of logic gates. The message-unit detected line is connected to a second input terminal of each logic gate of the second plurality of logic gates.

The message sub-unit state selection module further includes an encoder having an enable sub-unit 25 output bus-including a plurality of lines. Each line in the enable sub-unit output bus is connected to a third input terminal of a different logic gate in the second plurality of logic gates. A sub-unit selection register is connected to the encoder.

30 A method for configuring a pre-selected sub-unit of a message on-the-fly includes:

detecting the message using a hardware circuit in a device;

35       detecting a pre-selected message-unit of the message using the hardware circuit; and

configuring the pre-selected sub-unit of the pre-selected message-unit of the message to a pre-selected state using the hardware circuit as the pre-selected message-unit is passed through the 5 device.

While a pre-selected sub-unit in a pre-selected unit is manipulated on-the-fly, in one embodiment, in another embodiment, multiple pre-selected sub-units in the pre-selected unit are manipulated on-the-fly. In 10 still another embodiment, pre-selected sub-units in multiple pre-selected units are manipulated on-the-fly. In still another embodiment, any or all of these actions are performed on-the-fly on multiple messages. Hence, the use of a specific message, a specific pre- 15 selected unit in that message, and a pre-selected sub-unit in that unit is illustrative only and is not intended to limit the invention to this specific embodiment.

20 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is an illustration of a prior art system that includes a SCSI initiator that does not support AAF signal conditioning, a SCSI expander that does not support AAF signal conditioning, and a SCSI target that 25 does not support AAF signal conditioning.

Fig. 1B is an illustration of a prior art system that includes a SCSI initiator that does not support AAF signal conditioning, a SCSI expander that does not support AAF signal conditioning, and a SCSI target that 30 supports AAF signal conditioning that results in an incorrect configuration in the SCSI phase DATA OUT.

Fig. 1C is an illustration of a prior art system that includes a SCSI initiator that supports AAF signal conditioning, a SCSI expander that does not support AAF 35 signal conditioning, and a SCSI target that does not

support AAF signal conditioning that results in an incorrect configuration in the SCSI phase DATA IN.

Fig. 1D is an illustration of a prior art system that includes a SCSI initiator that supports AAF signal conditioning, a SCSI expander that does not support AAF signal conditioning, and a SCSI target that supports AAF signal conditioning that results in an incorrect configuration in the SCSI phases DATA OUT and DATA IN.

Fig. 2A is an illustration of a system that includes one embodiment of a SCSI expander of the present invention with a message manipulation circuit.

Fig. 2B is an illustration of a system that includes a SCSI initiator that does not support AAF signal conditioning, one embodiment of a SCSI expander of the present invention that does not support AAF signal conditioning, and a SCSI target that does not support AAF signal conditioning.

Fig. 2C is an illustration of a system that includes a SCSI initiator that does not support AAF signal conditioning, one embodiment of a SCSI expander of the present invention that does not support AAF signal conditioning, and a SCSI target that supports AAF signal conditioning.

Fig. 2D is an illustration of a system that includes a SCSI initiator that supports AAF signal conditioning, one embodiment of a SCSI expander of the present invention that does not support AAF signal conditioning, and a SCSI target that does not support AAF signal conditioning.

Fig. 2E is an illustration of a system that includes a SCSI initiator that supports AAF signal conditioning, one embodiment of a SCSI expander of the present invention that does not support AAF signal conditioning, and a SCSI target that supports AAF signal conditioning.

Fig. 2F is an illustration of a system that includes a SCSI initiator that does not support AAF signal conditioning, one embodiment of a SCSI expander of the present invention that supports AAF signal 5 conditioning, and a SCSI target that does not support AAF signal conditioning.

Fig. 2G is an illustration of a system that includes a SCSI initiator that does not support AAF signal conditioning, one embodiment of a SCSI expander 10 of the present invention that supports AAF signal conditioning, and a SCSI target that supports AAF signal.

Fig. 2H is an illustration of a system that includes a SCSI initiator that supports AAF signal 15 conditioning, one embodiment of a SCSI expander of the present invention that supports AAF signal conditioning, and a SCSI target that does not support AAF signal conditioning.

Fig. 2I is an illustration of a system that 20 includes a SCSI initiator that supports AAF signal conditioning, one embodiment of a SCSI expander of the present invention that supports AAF signal conditioning, and a SCSI target that supports AAF signal conditioning..

Fig. 3 is a detailed diagram of one embodiment of 25 the SCSI message manipulation circuit of the present invention.

Fig. 4A is one embodiment of clocking the counter of Fig. 3.

Fig. 4B is another embodiment of clocking the 30 counter of Fig. 3.

Fig. 4C is a timing diagram for assisting in the understanding of the clocking of the counter of Fig. 3.

In the drawings and the following detailed 35 description, elements with the same reference numeral are the same or similar elements. Also, the first

digit of a reference numeral for an element is the number of the figure in which that element first appears.

5    DETAILED DESCRIPTION

According to one embodiment of the present invention, a SCSI message manipulation circuit 250 in a SCSI expander 200A (Fig. 2A) detects a specified SCSI message from either a SCSI initiator 201, or a SCSI target 202. After detecting the specified SCSI message, SCSI message manipulation circuit 250 detects a pre-selected message-unit, e.g., a byte, within the message. Upon detecting the pre-selected message-unit, SCSI message manipulation circuit 250 sets a pre-selected sub-unit, e.g., a bit, within the pre-selected message-unit to a pre-selected state, which is programmable, as the SCSI message passes through SCSI expander 200A.

Specifically, the message content is manipulated on-the-fly, which means that the message is not stored, manipulated, and then released, as the message content is transferred through a device. The message manipulation circuit of this invention can be used in any device as the message is transferred through the device from an I/O bus or other communication medium.

A pre-selected sub-unit in a pre-selected unit is manipulated on-the-fly, in one embodiment. In another embodiment, multiple pre-selected sub-units in the pre-selected unit are manipulated on-the-fly. In still another embodiment, pre-selected sub-units in multiple pre-selected units are manipulated on-the-fly. In still another embodiment, any or all of these actions are performed on-the-fly on multiple messages. Hence, the use of a specific message, a specific pre-selected unit in that message, and a pre-selected sub-unit in

that unit is illustrative only and is not intended to limit the invention to this specific embodiment.

In one embodiment, as explained more completely below, the specified SCSI message is a Parallel Protocol Request (PPR) message, the pre-selected message-unit is a specific byte in the PPR message, and the pre-selected sub-unit is the precompensation enable control bit P\_EN in the specific byte. However, SCSI message manipulation circuit 250, or an equivalent of circuit 250 can be used for multiple SCSI messages as well as for multiple message-unit and sub-unit sizes within the messages. In general, message manipulation circuit 250 can be utilized in any configuration where it is desired to modify content of a message that is being transmitted between two devices, i.e., the message content is manipulated on-the-fly.

SCSI message manipulation circuit 250 does not affect any SCSI message other than the specified SCSI message. In addition, SCSI message manipulation circuit 250 does not adversely affect SCSI message throughput latency.

As explained more completely below, SCSI expander 200A can be used with any desired combination of SCSI devices with and without adjustable active filtering. Consequently, when SCSI message manipulation circuit 250 is included in any SCSI expander with or without adjustable active filtering, the prior art problems associated with a SCSI expander not supporting adjustable active filtering are eliminated without affecting the message handling performance of the SCSI expander. Figs. 2B to 2E are illustrations of various system configurations with a SCSI expander 200B that does not support adjustable active filtering, but that does include SCSI message manipulation circuit 250. In Figs. 2B to 2E, SCSI buses 291 and 292 are illustrated separately for SCSI

bus phases DATA IN and DATA OUT for convenience in illustrating the various states of precompensation enable bit P\_EN for the various configurations, and this should not be interpreted as requiring two 5 different buses to connect the expander of this invention to a SCSI device.

Prior art SCSI expander 100 supported a system configuration having only SCSI initiators and SCSI targets that did not support adjustable active 10 filtering signal conditioning. As explained more completely below, any SCSI target or SCSI initiator independent of the type of signal conditioning supported can be used with SCSI expander 200B.

For example, in Fig. 2B, SCSI expander 200B 15 (Fig. 2B) is used in a system configuration having only SCSI initiators and SCSI targets that do not support adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI target 202B sets precompensation enable control bit P\_EN in the PPR message that is passed to 20 SCSI expander 200B. In SCSI expander 200B, the PPR message is passed through SCSI bus two interface 220, which turns on write precompensation, to SCSI message manipulation circuit 250. SCSI message manipulation circuit passes the PPR message without modification to 25 SCSI bus one interface circuit 210 that in turns passes the unmodified PPR message to SCSI initiator 201B. In response to the PPR message, SCSI initiator 201B turns on write precompensation.

For a SCSI bus phase DATA IN, SCSI initiator 201B 30 sets precompensation enable control bit P\_EN in the PPR message that is passed to SCSI expander 200B. In SCSI expander 200B, the PPR message is passed through SCSI bus one interface 210, which turns on write precompensation, to SCSI message manipulation circuit 250. SCSI message manipulation circuit passes the PPR message without modification to SCSI bus two interface 35

circuit 220 that in turns passes the unmodified PPR message to SCSI target 202B. In response to the PPR message, SCSI target 202B turns on write precompensation.

5 Hence, the system configuration of Fig. 2B works successfully with SCSI expander 200B. In addition, as shown below, when a system includes either a SCSI initiator, a SCSI target, or both that supports adjustable active filtering signal conditioning, SCSI expander 200B correctly interacts with each device.

In particular, as illustrated in Fig. 2C, SCSI target 202C supports adjustable active filtering and SCSI initiator 201B does not support adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI 15 target 202C negates precompensation enable control bit P\_EN in the PPR message that is sent to SCSI expander 200B over SCSI bus 292. The PPR message is routed through SCSI bus two interface 220, which turns off write precompensation in response to the PPR 20 message, and routes the PPR message to SCSI message manipulation circuit 250 that in turn routes a modified PPR message to SCSI bus one interface circuit 210.

SCSI message manipulation circuit 250, as explained more completely below, changes the state of 25 precompensation enable control bit P\_EN in the PPR message on-the-fly from negated to asserted.

Otherwise, the message is passed unchanged by circuit 250 to SCSI bus one interface circuit 210. SCSI bus one interface circuit 210 passes the modified 30 PPR message over SCSI bus 291 to SCSI initiator 201B that in turn turns on write precompensation. Hence, the modified PPR message correctly indicates to SCSI initiator 201B that SCSI expander 202B requires write precompensation.

35 For a SCSI bus phase DATA IN (Fig. 2C), SCSI initiator 201B sets precompensation enable control

bit P\_EN in the PPR message that is passed to SCSI expander 200B. In SCSI expander 200B, the PPR message is passed through SCSI bus one interface 210, which turns on write precompensation, to SCSI message manipulation circuit 250. SCSI message manipulation circuit passes the PPR message without modification to SCSI bus two interface circuit 220 that in turns passes the unmodified PPR message to SCSI target 202C. In response to the PPR message, SCSI target 202C turns on write precompensation. Hence, unlike the prior art system of Fig. 1B, the correct signal conditioning is used for each segment of the path between SCSI initiator 201B that does not support adjustable active filtering to SCSI target 202C that supports adjustable active filtering.

As illustrated in Fig. 2D, SCSI initiator 201C uses adjustable active filtering and SCSI target 202B does not support adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI target 202B sets precompensation enable control bit P\_EN in the PPR message that is passed to SCSI expander 200B. In SCSI expander 200B, the PPR message is passed through SCSI bus two interface 220, which turns on write precompensation, to SCSI message manipulation circuit 250. SCSI message manipulation circuit passes the PPR message without modification to SCSI bus one interface circuit 210 that in turns passes the unmodified PPR message to SCSI initiator 201C. In response to the PPR message, SCSI initiator 201C turns on write precompensation.

For a SCSI bus phase DATA IN (Fig. 2D), SCSI initiator 201C negates precompensation enable control bit P\_EN in the PPR message that is sent to SCSI expander 200B over SCSI bus 291. SCSI bus one interface 210, which turns off write precompensation, routes the PPR message to SCSI message manipulation

circuit 250 that in turn routes a modified PPR message to SCSI bus two interface circuit 220.

SCSI message manipulation circuit 250, as explained more completely below, changes the state of 5 precompensation enable control bit P\_EN in the PPR message. Otherwise, the message is passed unchanged by circuit 250. SCSI bus two interface circuit 220 passes the modified PPR message over SCSI bus 292 to SCSI target 202C. Hence, the PPR modified message correctly 10 indicates to SCSI target 202B that SCSI expander 202B requires write precompensation. Hence, unlike the prior art system of Fig. 1C, the correct signal conditioning is used for each segment of the path between SCSI initiator 201C that supports adjustable 15 active filtering to SCSI target 202B that does not support adjustable active filtering.

As illustrated in Fig. 2E, both SCSI initiator 201C and SCSI target 202C support adjustable active filtering. For a SCSI bus phase DATA OUT, SCSI 20 target 202C negates precompensation enable control bit P\_EN in the PPR message that is sent to SCSI expander 200B over SCSI bus 292. The PPR message is routed through SCSI bus two interface 220, which turns off write precompensation in response to the PPR 25 message, and routes the PPR message to SCSI message manipulation circuit 250 that in turn routes a modified PPR message to SCSI bus one interface circuit 210.

SCSI message manipulation circuit 250, as explained more completely below, changes the state of 30 precompensation enable control bit P\_EN in the PPR message on-the-fly from negated to asserted. Otherwise, the message is passed unchanged by circuit 250 to SCSI bus one interface circuit 210. SCSI bus one interface circuit 210 passes the modified 35 PPR message over SCSI bus 291 to SCSI initiator 201C that in turn turns on write precompensation. Hence,

the modified PPR message correctly indicates to SCSI initiator 201C that SCSI expander 200B requires write precompensation.

For a SCSI bus phase DATA IN (Fig. 2E), SCSI initiator 201C negates precompensation enable control bit P\_EN in the PPR message that is sent to SCSI expander 200B over SCSI bus 291. SCSI bus one interface 210, which turns off write precompensation, routes the PPR message to SCSI message manipulation circuit 250 that in turn routes a modified PPR message to SCSI bus two interface circuit 220.

SCSI message manipulation circuit 250, as explained more completely below, changes the state of precompensation enable control bit P\_EN in the PPR message. Otherwise, the message is passed unchanged by circuit 250. SCSI bus two interface circuit 220 passes the modified PPR message over SCSI bus 292 to SCSI target 202C. Hence, the PPR modified message correctly indicates to SCSI target 202C that SCSI expander 202B requires write precompensation. Hence, unlike the prior art system of Fig. 1D, the correct signal conditioning is used for each segment of the path between SCSI initiator 201C that does support adjustable active filtering to SCSI target 202C that also supports adjustable active filtering.

Prior art Figs. 1A to 1D illustrated the problems encountered when a SCSI expander 102 that did not support adjustable active filtering was used in systems that included devices that utilized adjustable active filtering signal conditioning. TABLE 1 summarizes the problems when the prior art SCSI expander 102 is replaced with a prior art SCSI expander that supports adjustable active filtering (not shown).

TABLE 1. Prior Art SCSI Expander that Supported Adjustable Active Filtering

Initiator Signal Conditioning	Target Signal Conditioning	SCSI Bus Phase	P_EN State in Message to Expander (Prior Art)	P_EN State in Message From Expander (Prior Art)
WPC (Fig. 1A)	WPC	Data Out	Asserted	Asserted (Incorrect)
		Data In	Asserted	Asserted (Incorrect)
WPC (Fig. 1B)	AAF	Data Out	Negated	Negated
		Data In	Asserted	Asserted (Incorrect)
AAF (Fig. 1C)	WPC	Data Out	Asserted	Asserted (Incorrect)
		Data In	Negated	Negated
AAF (Fig. 1D)	AAF	Data Out	Negated	Negated
		Data In	Negated	Negated

- 5 Hence, as shown by TABLE 1, the prior art SCSI expander that supported adjustable active filtering could only be used successfully in systems where both the SCSI initiators and the SCSI targets supported adjustable active filtering signal conditioning.
- 10 In another embodiment of this invention, SCSI expander 200B in Figs. 2B to 2E is replaced with another SCSI expander 200F that supports adjustable active filtering signal conditioning. With SCSI expander 200F, the problems in TABLE 1 are eliminated,
- 15 as illustrated by TABLE 2. Figs. 2F to 2I are illustrations of various system configurations in TABLE 2 for a SCSI expander 200F that supports

adjustable active filtering and also includes SCSI message manipulation circuit 250.

5 TABLE 2. SCSI Expander that Supports Adjustable Active Filtering, and includes SCSI Message Manipulation Circuit

Initiator Signal Conditioning	Target Signal Conditioning	SCSI Bus Phase	P_EN State in Message to Expander	P_EN State in Message From Expander
WPC	WPC	Data Out	Set	Negated
(Fig. 2F)		Data In	Set	Negated
WPC	AAF	Data Out	Negated	Negated
(Fig. 2G)		Data In	Set	Negated
AAF	WPC	Data Out	Set	Negated
(Fig. 2H)		Data In	Negated	Negated
AAF	AAF	Data Out	Negated	Negated
(Fig. 2I)		Data In	Negated	Negated

Hence, a SCSI expander 200F, which supports adjustable active filtering and includes SCSI message manipulation circuit 250, changes the state of precompensation enable control bit P\_EN in the PPR message to correctly indicate the type of signal conditioning required to communicate successfully with SCSI expander 200F as illustrated in Figs. 2F to 2I for each of the prior art incompatible configurations of TABLE 1. Conversely, for configurations that did not result in an incompatible configuration, SCSI expander 220F passes the PPR message through unmodified.

20 Returning to Fig. 2A, SCSI message manipulation circuit 250, in this embodiment, includes a message detector module 260 that detects when a selected message is being passed between a SCSI initiator and a SCSI target through SCSI expander 200A. In more

general terms, a message detector module detects a pre-selected message passing through a device. Upon detection of a message, module 260 generates an active signal on a message-detected line 261 to message sub-unit state selection module 280. Module 260, in some embodiments, also enables circuitry in message-unit detector module 270.

Herein, an active signal does not indicate any particular logic level. Each line in a circuit typically has a specific logic level defined as the active level and the negated logic level is the inactive level. Thus, an active signal for a particular line means the specific logic level defined as the active level for that line.

Message-unit detector module 270, in one embodiment, is programmably configured to detect a specified message-unit, sometimes called a pre-selected message-unit, in the detected message. In another embodiment, module 270 is hard-wired, sometimes called hard-coded, to detect a pre-selected message-unit in the detected message.

Here, a message-unit is a basic size metric associated with the message, e.g., a byte, a word, a double word, etc., or perhaps a particular packet in a multi-packet message. When the pre-selected message-unit of the message is detected, message-unit detector 270 generates an active signal on message-unit detected line 271 to message sub-unit state selection module 280.

In addition to input lines 261 and 271, message sub-unit state selection module 280 includes an optional enable input line 281 that is used in some embodiments. When the signals on input lines 261, 271 and 281 are active, in one embodiment, message sub-unit state selection module 280 sets the state of a programmably pre-selected sub-unit of the pre-selected

message-unit in the message to a programmably selected state as the pre-selected message-unit is passed through expander 200A. In another embodiment, the selected sub-unit is hard-coded in module 280. In 5 still another embodiment, enable input line 281 is not used and when the signals on lines 261 and 271 are both active, message sub-unit state selection module 280 sets the state of a programmably pre-selected sub-unit of the pre-selected message-unit in the message to a 10 programmably selected state as the pre-selected message-unit is passed through expander 200A.

When expander 200A is used for detecting a SCSI PPR message, the pre-selected message-unit is a specific byte in the message containing a 15 precompensation enable control bit, and the sub-unit is the precompensation enable control bit. The state of the precompensation enable control bit is set based upon the type of signal conditioning supported by expander 200A.

20 Fig. 3 is a more detailed diagram of one embodiment of SCSI message manipulation circuit 250 of this invention. This embodiment permits setting a bit in a message byte to a selected state. The bit in the message byte, the message byte, and the state of the 25 bit are programmably selectable, in this embodiment, i.e., are pre-selected.

Bus-in selector 380 passes the signals on one of buses 211 from SCSI bus one interface circuit 210 and bus 221 from SCSI bus two interface circuit 220 to an 30 input bus SDI[7:0] that includes a plurality of input lines. A signal level on a line DIRECT is used to select which of the two buses 211 and 221 is connected to bus SDI[7:0]. The signal level on line DIRECT is determined by the direction of data transfer through 35 SCSI expander 200.

In one embodiment, bus-in selector 380 is a multiplexer. In another embodiment, bus-in selector 380 is included within each of bus-interface circuits 210 and 220 and so input bus SDI[7:0] is connected to each of bus-interface circuits 210 and 220. The particular way that the input signals are selected and driven on input bus SDI[7:0] is not essential to this invention.

Each input line of bus SDI[7:0] is connected to a first input terminal of a different OR gate in a plurality of OR gates 340\_0 to 340\_7, e.g., a first plurality of logic gates, and to a first input terminal of a different AND gate in a plurality of AND gated 360\_0 to 360\_7, e.g., a second plurality of logic gates.

Each output line of an OR gate in plurality of OR gates 340\_0 to 340\_7 drives a different line in a bus 371 to multiplexer 370. Each output line of an AND gate in plurality of AND gates 360\_0 to 360\_7 drives a different line in a bus 372 to multiplexer 370. The signals driven on output bus SDO[7:0] from one of buses 371 and 372 are selected by a level of a signal POLARITY on line 375.

In one embodiment, if circuit 250 is included in an expander that does not support active adjustable filtering, the level of signal POLARITY is set, e.g., set active, so that multiplexer 370 connects bus 371 to output bus SDO[7:0] and disconnects bus 372 from output bus SDO[7:0]. Conversely, if circuit 250 is included in an expander that supports adjustable active filtering, the level of signal POLARITY is set, e.g., set inactive, so that multiplexer 370 connects bus 372 to output bus SDO[7:0] and disconnects bus 371 from output bus SDO[7:0]. The state of the signal on line 375 could be programmed by an on-chip processor, loaded

from an external source such as a SCSI initiator, or a host system, or alternatively hard-coded.

In general, an output terminal of each OR gate in plurality of OR gates 340\_0 to 340\_7 is selectively coupled to and selectively decoupled from a different output line of output bus SDO[7:0] by multiplexer 370. Similarly, an output terminal of each AND gate in plurality of AND gates 360\_0 to 360\_7 is selectively coupled to and selectively decoupled from a different output line of output bus SDO[7:0] by multiplexer 370, in this embodiment.

Output bus SDO[7:0] is connected to one of buses 211 and bus 221, in this embodiment, by a bus-out selector 390. One of buses 211 and 221 is selected by the signal level on line DIRECT and is the opposite of the bus selected by bus-in selector 380. Again, the particular way the signals on bus SDO[7:0] are output from SCSI expander 200A is not essential to this invention.

A second input terminal of each OR gate in plurality of OR gates 340\_0 to 340\_7 is connected to an output terminal of a different AND gate in a plurality of AND gates 330\_0 to 330\_7, e.g., a third plurality of logic gates. As explained more completely below, except when a message is being processed, the output signals from plurality of AND gates 330\_0 to 330\_7 are always inactive, e.g., low, so that plurality of OR gates 340\_0 to 340\_7 pass the signals on bus SDI[7:0] to bus 371.

A second input terminal of each AND gate in plurality of AND gates 360\_0 to 360\_7 is connected to an output terminal of a different NAND gate in a plurality of NAND gates 350\_0 to 350\_7, e.g., a fourth plurality of logic gates. As explained more completely below, except when a message is being processed, the output signals from plurality of NAND gates 350\_0

to 350\_7 are always active, e.g., high, so that plurality of AND gates 360\_0 to 360\_7 pass the signals on bus SDI[7:0] to bus 372.

Hence, independent of the state of  
5 signal POLARITY on line 375, during non-message processing operation of expander 200A, circuit 250 passes the data without modification from input bus SDI[7:0] to output bus SDO[7:0]. Preferably, circuit 250 is designed such that the data timing of  
10 pass-through signals is not corrupted, which can be done with conventional design and layout tools.

A message decode circuit 301 monitors information passing through expander 200A on line 302. As is known to those of skill in the art, monitoring the SCSI bus phase and request and acknowledge signals on the SCSI bus are used to determine when a message is present.  
15 Moreover, in the message phase, the specific byte sequences are specified by the SCSI specification and also are known to those of skill in the art. Message decode circuit 301 detects the first two bytes of a PPR message, and in response thereto drives an active signal on message-detected line 261 for the duration of the message. At other times, the signal level on line 261 from message decoder 301 is inactive, in this  
20 embodiment. Message detected line 261 is connected to a first input terminal of each AND in plurality of AND gates 330\_0 to 330\_7 and to a first input terminal of each NAND gate in plurality of NAND gates 350\_0 to 350\_7.

30 After a message is detected by decoder 301, an active signal is driven on line BYTE\_EN to a counter 310. Counter 310 is clocked by a signal CLK on line 312 to counter 310 as each byte is transferred to expander 200A.

35 Various alternative embodiments can be used to clock counter 310. In a first embodiment, illustrated

in Fig. 4A, signal CLK is generated using the request signal REQ or acknowledge signal ACK depending on the direction of data transfer, as illustrated in Fig. 4C. In this embodiment, line 261 is connected directly to 5 line 311.

In the embodiment of Fig. 4B, signal CLK is a free running clock. In this embodiment, counter 310 receives the enable signal on line 261 and in addition receives a count enable signal on line 311 from valid 10 message unit decoder 401. In addition, for the message of interest in this embodiment, counter 310 is either loaded with a value of two, or alternatively, the value loaded in message-unit selection register 314 is the number bytes after counter 310 starts to count, and not 15 the specific number of bytes in the message. In view of these examples, those of skill in the art can implement various configurations to provide the proper signal level and timing on line 271.

Hence, counter 310 counts each byte in the PPR 20 message following detection of the message. The value of counter 310 is a first input to a comparator 315. A second input to comparator 315 is a value BYTENUM in a message-unit selection register 314. Register 314 could be loaded by an on-chip processor, loaded from an 25 external source such as a SCSI initiator, or a host system, or alternatively hard-coded. The way that a particular value is loaded in message-unit selection register 314 is not essential to this invention.

When the value from counter 310 equals value 30 BYTENUM, e.g., when a value of counter 310 has a predefined relationship to the value stored in register 314, comparator 315 generates an active signal on message-unit detected line 271. This indicates that the message-unit containing the sub-unit of interest is 35 on input bus SDI[7:0]. Alternatively, the signal on line 271 could indicate that the next message-unit on

bus SDI[7:0] is the message-unit of interest. Again, the particular way chosen to modify the message-unit on-the-fly depends on the timing constraints introduced by the circuit in combination with the timing

5 requirements for the buses connected to the expander.

Message-unit detected line 271 is connected to a second input terminal of each AND gate in plurality of AND gates 330\_0 to 330\_7 and to a second input terminal of each NAND gate in plurality of NAND gates 350\_0

10 to 350\_7. Hence, circuit 250 detects a message and then a particular message-unit within the message, e.g., a pre-selected byte within the message, as indicated by the output signals from decoder 301 and comparator 315, respectively.

15 A value BITNUM in a sub-unit selection register 321 is a first input to an encoder 320. Encoder 320 drives an enable sub-unit output bus EN\_BIT[7:0]. Specifically, encoder 320 drives an active signal on the line of enable sub-unit output bus

20 EN\_BIT[7:0] corresponding to value BITNUM in register 321 and the signals on the other lines of bus EN\_BIT[7:0] are held inactive.

Each line of enable sub-unit output bus EN\_BIT[7:0] is connected to a third input terminal of a different AND gate in plurality of AND gates 330\_0 to 330\_7 and to a third input terminal of a different NAND gate in plurality of NAND gates 350\_0 to 350\_7. Hence, the AND gate corresponding to the value in register 321 receives the active signal from

30 encoder 320, and generates an active signal on the second input terminal of the OR gate to which it is connected. This OR gate, in turn, generates an active signal on the line of bus 371 corresponding to the value in register 321. Similarly, the NAND gate

35 corresponding to the value in register 321 receives the active signal from encoder 320, and generates an active

signal on the second input terminal of the AND gate to which it is connected. This AND gate, in turn, generates an inactive signal on the line of bus 372 corresponding to the value in register 321. Hence, the 5 sub-unit of bus 371 that is defined by the value in sub-unit selection register 321 is set to a first selected value, and the sub-unit of bus 372 that is defined by the value in sub-unit selection register 321 is set to a second selected value.

10 Various alternative embodiments of the SCSI message manipulation circuit can be implemented in view of this disclosure.. For example, if circuit 250 is being implemented in an device that uses only one type of signal conditioning either logic gates 330\_0 15 to 330\_7 and 340\_0 to 340\_7, or logic gates 350\_0 to 350\_7 and 360\_0 to 360\_7 can be eliminated along with multiplexer 370 and the polarity control signal. This configuration still allows selecting any sub-unit 20 of any message unit in the message, but the state of the selected sub-unit is fixed.

The logic can be simplified further if the sub-unit of interest is always the same sub-unit in the same message unit, e.g., bit seven of the last message byte. In this case, the logic always forces bit seven 25 of the last message byte to a selected value as bit seven leaves the expander. Therefore, the embodiments described herein are illustrative only and are not intended to the limit the invention to the specific 30 embodiments described.

For example, the message manipulation circuit can be expanded to change multiple bits within a byte, multiple bytes, or even multiple messages. In one embodiment of message unit detector 270, comparator 315 represents a plurality of comparators, line 271 35 represents a plurality of lines with one output line from each comparator in the plurality, and register 314

represents a plurality of registers. Similarly, register 321 represents a plurality of registers. In this embodiment, each line in the plurality of lines 271 also goes to encoder 320 to select the sub-unit 5 number in the corresponding one of the registers in the plurality of registers 321. This configuration permits modifying multiple message units on-the-fly, modifying multiple sub-units in a message unit on-the-fly, or a combination of the two.

10 If modifying multiple messages on-the-fly is of interest, message decoder 301 represents a plurality of message decoders with each message decoder providing an enable signal to message unit detector 270. The enable signal to message unit detector 270 is used to select 15 different message units from plurality of registers 314, or alternatively, to select a set of registers if multiple units in the message are to be changed. In view of Fig. 3, modifications can be made by those of skill in the art to handle less complicated, or more 20 complicated message manipulation. However, in each instance, the content of the message is detected on-the-fly, and modified on-the-fly.